APPLICATION FOR UNITED STATES PATENT

in the name of

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Of

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For

Delivery Information Systems and Methods

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DELIVERY INFORMATION SYSTEMS AND METHODS

BACKGROUND

The Internet has become a significant medium for communication and commerce and has enabled millions of people to share information and conduct business electronically. The unique characteristics of the Internet such as its ability to provide enhanced communication, rich text, and graphic environment provide an ideal support for a wide variety of electronic commerce transactions. For example, a consumer can search, review, and extensively shop a number of competing chains in an instant. As such, consumers benefit by being able to obtain a good price relatively quickly and easily.

On-line retailers also benefit, since these retailers can carry a larger number of products at a lower cost and with greater merchandising flexibility without the physical constraints faced by traditional retailers. Additionally, they can assist the consumer's purchase decision by providing relevant information and enabling consumers to shop at their convenience by remaining open 24 hours a day, seven days a week. Online retailers can also provide personalized services and use direct marketing efforts based on information provided by customers.

As such, the Internet has evolved into a unique sales and marketing channel. The ubiquity and convenience of the Internet makes it ideal for dispensing information on certain topics that traditionally require visits to specialists. For example, certain consumers may be interested in products and services associated with orthodontics and dentofacial orthopedics that specializes in the diagnosis, prevention and treatment of dental and facial irregularities ("malocclusion" or "bad bite"). The orthodontic treatment process typically uses corrective appliances such as braces and/or other fixed or

removable appliances to bring the teeth, lips and jaws into proper alignment and to achieve a facial balance. The pervasiveness of the Internet makes it an ideal source for information relating to these products and services.

SUMMARY

Systems and methods support dental patient scheduling relating to one or more dental appliances by communicating manufacturing progress information with a patient computer over a wide area network; and performing patient scheduling when one or more dental appliances reach a predetermined manufacturing progress.

In one aspect, a system supports dental patient scheduling with a network to communicate information relating to a manufacturing stage; one or more patient computers coupled to the network; and a server coupled to the network, the server communicating manufacturing progress information with the patient computer and performing patient scheduling when one or more dental appliances reach a predetermined manufacturing progress.

Implementations of the system may include one or more of the following. The server can send a message to a patient when the appliances reach a predetermined manufacturing stage. The message can be sent when the appliances are being marked. The server can send a message to a treating professional when the appliances reach one or more intermediate stages of manufacturing. The server can send an electronic mail message to transmit information relating to manufacturing progress. The server can maintain calendar pages for the treating professionals. The server can invite a patient to access an on-line calendar and schedule an appointment when the appliances reach the

last stage of manufacturing. A network of treating professionals can be accessed using the network. The server can request intervention from manufacturing personnel when one or more manufacturing stages fall behind schedule and can update the patient with information relating to a delay caused by manufacturing slippage.

Advantages of the system may include one or more of the following. For treating professionals and patients, the system provides a convenient way to communicate information, including scheduling information. The system also enables people to share their schedules with the treating professional. The system is convenient to use and provides informative treatment experience through which dental care services and dental-related products can be dispensed. Consumers can access the system using an intuitive, easy-to-use interface that is available 24 hours a day, seven days a week and from anywhere Internet access is available.

The system quickly reports to a user such as a treating professional or a patient the status of the manufacturing operations. If a particular manufacturing operation is late or early, the user can adjust his or her schedule appropriately. This is done without requiring a person to call the user and communicate the delivery date. The system allows the orthodontist and the patient sufficient lead-time to schedule an appointment.

The system also eliminates resources required to automatically inform users and manufacturing personnel of manufacturing status. This operation is done cost-effectively without requiring human operators to keep track of delivery information and to physically call users in case the manufacturing of the appliances falls behind schedule

The system is also efficient to use for treating professionals such as orthodontists. An orthodontist can simply log-in to the system, open his or her on-line calendar, pick up

the patient's folder on the system and review the status of the case. The treating professional reduces the professional's overhead in that patients directly schedule the appointment without having to coordinate availability with a receptionist.

Correspondingly, patients also experience higher quality of service since he or she can log-in, monitor the progress of the production of his or her appliances, and schedule appoints if necessary. These operations can be done anywhere and at any time, as long as the patients and the treating professionals have access to the Internet.

The system supports a virtual community of dental patients, dentists, specialists such as orthodontists and oral surgeons, financial institutions, benefit providers and the providers of dental equipment or services. For treating professionals, such as dentists and orthodontists, the system provides a one-stop solution for planning patient treatments, managing communication with patients, storing patient records and sharing records with relevant persons outside the doctor's office.

Aspects of the final treatment plan can be used to generate appliances used in the physical treatment. The information associated with the patient's treatment (visual images, virtual treatment plans, file notes and the like) are digitized and maintained in a central storage facility in a secure manner. Doctors and patients can have access to these files without the need to extract files and models from storage and with reduced risk of records being misplaced.

Administratively, the system allows the office to be managed more efficiently without requiring the treating professional to purchase and maintain special software. The system keeps track of all patients that need to be contacted for an appointment. Scheduling can be done automatically or can be customized to the office's preference and

availability of treating professionals and supporting resources. Based on the appointments, the system can electronically mail (email) patients with reminders. Alternatively, the system can print reminder cards that can be mailed to patients reminding them of their appointment. The system can also automatically generate personalized correspondence to patients relating to data collected in the initial exam and treatment recommendations. Moreover, the patient can review the proposed treatment with the treating professional anywhere.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram of an exemplary environment supporting electronic commerce.

Fig. 2 is a diagram of a server to support scheduling operations.

Fig. 3 is a diagram of a web site on the server of Fig. 2.

Fig. 4 is a flowchart of a process to produce a dental appliance.

Fig. 5 shows a system for making the dental appliance.

Fig. 6A is a flowchart of a first process for scheduling dental related appointments.

Fig. 6A is a flowchart of a second process for scheduling dental related appointments.

Fig. 6B shows a second embodiment of a system for producing appliances and scheduling appointments.

Figs. 7A-7B are flowcharts of a process to generate treatment plans and to schedule appointments when appliances are ready for delivery.

Fig. 8 is a diagram illustrating a computer system to support the fabrication of appliances.

DESCRIPTION

Referring now to Fig. 1, an environment supporting a dental system 100 is shown. The system 100 communicates over a network 102 that can be a local area network or a wide area network such as the Internet.

One or more client computers 104-105 can be connected to the network 102. In one embodiment where the network 102 is the Internet, the client computers execute a suitable browser such as Navigator from Netscape, Inc. and Internet Explorer from Microsoft Corp. By clicking on the highlighted text (or specific graphic image), the user can jump from the current web page to a new web page address associated with the link--with the new page displayed on the screen. In this manner, the user can "surf the web" by clicking on an almost endless succession of links going to page after page all following a common thread as defined by the text or graphic component of the link label.

Through the network 102, the client computers 104-105 can access a dental server 106. The dental server 106 serves a web site, a portal, a vertical portal (vortal), or a content site for providing dental related information to interested parties such as dental patients, dentists, orthodontists, and others. When sensitive information is communicated through the dental server 106, such information is securely encrypted using Secure Sockets Layer (SSL) technology throughout the transaction. The server 106 can be a stand-alone computer or can be a server farm that can distribute processing and communications activity across a computer network so that no single device is

overwhelmed. During load balancing, if one server is swamped with requests, excess requests are forwarded to another server with more capacity.

The network 102 connects the dental server 106 to one or more treating professional workstations 108-109. The workstations 108-109 allow treating professionals access to a plethora of services provided by the dental server 106 such as patient treatment and office management, among others. The dental server 106 stores information associated with patient history on-line in a secure manner. The server 106 also allows the treating professional to have a comprehensive view of the patient's treatment history at any time using a suitable browser, eliminating the need to pull treatment files or charts or to look for misfiled or lost charts. The dental server 106 also provides treating professionals with tools to analyze patient data, for example, tools to reconstruct a 3D model of the teeth. For example, using the browser, the treating professional can request the server 106 to animate the progress of the treatment plan. When the treating professional arrives at a prescription or other final designation, the treatment prescription is used to automatically generate appliances, as described in more details below. Further, in addition to aiding professionals in treating patients, the treating professional can perform office management, purchasing and other logistical operations using the browser and the dental server 106.

In addition to communicating with patients and treating professionals, the dental server 106 can communicate with one or more partners 110 using the network 102. The partners 110 can be product suppliers, service providers, or any suitable commercial entities.

One partner 110 can be a financing partner that offers customers with one or more electronic financing options. In one implementation, the financing partner can be a credit card processing company. The credit card processing company can accept a customer's existing credit card or can issue the customer with a new credit card. Further, the credit card can be issued under the name of a third-party bank, the name of the credit card processing company, or the name of the site supported by the dental server 106 under a co-branding arrangement.

The customer enters the sensitive data such as credit card number, shipping address, among others, onto a purchase form. The credit data is then submitted, collected and passed securely through the dental server 106. This data can be processed in real time or can be collected by mail or telephone and then entered by an operator. A processor at the credit card processing company then verifies that the credit card number is valid and is not stolen, among other anti-fraud measures. If the credit card information is valid, the purchase price will be reserved from the issuing bank of the consumer's credit card and allocated to the account associated with the server 106. Periodically, the credit card processor settles all accounts; it is at this time that all monies move. Funds reserved are transmitted from the issuing bank of the cardholder's credit card to the account of the server 106. Also, discount fees are paid from these funds, as they are moving.

Alternatively, the financing partner can debit from the customer's checking account over the Internet. One such check debiting services is the MerchanTrust™ Paperless Checks™ Services, available from Merchant Commerce, Inc. These services provide customers with the convenience of making online purchases by checking account debits, with no manual data entry required of a merchant. In this embodiment, a

customer fills in a form at the site with bank information printed at the bottom of his or her personal check. The information is processed as an Electronic Funds Transfer (EFT) to the customer's account using the Automated Clearinghouse (ACH) payment system.

Yet another possible partner 110 is a dental supply retailer providing an on-line shop on the web site to retail dental products to the customers and treating professionals. The retailer can be a co-branding partner that uses the brand name linked or suitably associated with the web site of the server 106 such that users of the server 106 would not know that the on-line shop is actually operated by a third party. The retailer can offer dental products for brushing, flossing, and cleaning of dental implants and bridges. Other dental products include anti-plaque rinse and plaque-fighting toothpaste. The retailer can also sell other health-care-related products such as prescription drugs; non- prescription drugs; personal care; beauty and spa; vitamins, herbs and nutrition; and medical supplies. Additionally, the retailer can serve the needs of the treating professionals by offering products such as brackets, buccal tubes, bands, archwire products, bonding adhesives, hand instruments, systems, supplies and equipment.

Yet another partner 110 can be a shipping partner. The shipping partner delivers dental supply or goods received from a multiplicity of producers and manufacturers for ultimate distribution to each customer. The facilities for warehousing and introduction of goods into a transportation stream for redistribution are the so-called cross docking facilities. The supply or good flows in bulk from a producer or a manufacturer to one or more cross docking facilities owned by either the shipping partner or the operator of the server 106. The items are then be broken into smaller unit sizes and distributed to the customers.

The above list of partners lists only exemplary partners and is not an exhaustive list. Other possible partners include value-added service providers such as third party software providers who provide plug-in viewing and diagnostic enhancements that can be used by the professionals.

In addition to performing orthodontic operations, the server 106 can also perform other value-added services. For example, processes executed by the server 106 can simulate the color of the patient's enamel and show the color of the teeth before and after bleaching. Further, processes on the server 106 can simulate the color of the patient's silver fillings (amalgram) and show the teeth after cosmetic work to cover the amalgam. Once the patient has accepted a particular treatment selection, the server 106 offers the patient with one or more financing options from one of its financial partners. Additionally, the server 106 can guide the patient to an on-line shopping store to purchase products relating to his or her dental health. For example, the patient can buy cleaning supplies, brushes, and flossing supply at a price competitive to his or her traditional stores. Moreover, the products can be delivered to the patient using one or more delivery partners at a convenient time.

The server 106 can perform dynamic targeting and information gathering. The users provide demographic information when they register for our service. The server 106 can track our users' behavior the entire time they are online. As a result, the server 106 can deliver targeted advertisements and measure their effectiveness. For example, users can receive ads from a brokerage firm when they are viewing sites containing stock quotes or financial news, or receive promotions from a bookseller when browsing sites containing book reviews. As such, the dental server 106 can provide a prominent and

sustained advertising medium to the community. In contrast to most portal and content sites which display advertising, the site remains with users the entire time they are online. Once users are logged on, the site remains in full view throughout the session, including when they are waiting for pages to download, navigating the Internet and even engaging in non-browsing activities such as sending or receiving e-mail. The constant visibility of the site allows advertisements to be displayed for a specified period of time.

In combination, the dental server 106 forms a hub that links dental clients using client computers 104-105, treating professionals using workstations 108-109, and partners 110 into a living electronic commerce (e-commerce) community.

Fig. 2 shows an embodiment of the server 106. The server 106 includes a web server 140, a patient information server 142, a resource planning (RP) server 144 and a streaming server 146. In one embodiment, the RP server 144 runs Microsoft SQL server and provides information relating to a doctor or a patient such as address and history. When a patient's case or static snapshots of the case is needed, the data is pulled from the patient information server 142. When media data such as video needs to be streamed to a requesting client, the streaming server 146 can send the stream. In one implementation, the streaming data is stored in QuickTime format on a Linux-based server running the QuickTime server software.

The servers can be clustered. In one embodiment using Microsoft's Cluster Server, cluster-enabled applications such as Microsoft's SQL Server and Exchange. With Cluster Server, two servers can run applications at the same time. When one server fails, the remaining server handles its application as well as the failed server's applications. Next, the remaining server adopts the IP address of the failed server and mounts one or

more data drives that the two systems share. The remaining server is rebooted and applications such as SQL Server can be started and initialized on this server. Persistent clients can re-attach to the server and continue to operate.

Referring now to Fig. 3, a diagram 200 shows various major functions supported by the dental server 106. First, the process 200 performs an automatic detection for the existence of a browser welcome plug-in (step 202). If the welcome plug-in exists, an introductory animation (flash) is shown (step 204). From step 204 or 206, the process 200 shows a home page (step 206) with one or more links. A link is created by having a word in a text field (or a graphic image on a web page) linked to the location of another web page, via a string of information setting forth the new web page address presented in hypertext transfer protocol (HTTP), among others.

The user can navigate the home page to join a particular site from a constellation of related sites. For instance, the user can navigate to a patient's site (step 208), a doctor's site (step 210), a privacy statement site (step 212), one or more additional sites (step 214), and an about site (step 216), among others. The additional sites can be an on-line shopping store that is co-branded with the web site hosted by the server 106, or the on-line shopping store can be directly affiliated with a third party such as planet-rx.com, among others. The additional sites can also be third party value-added providers of products and/or services.

In one embodiment, during start-up, a browser checks for a viewer plug-in module in a "plugins" subdirectory (Windows) or Plug-ins folder (Mac OS) in the same folder or directory as the browser. If the viewer plug-in module is available, the browser looks for a MIME type and extension info from the version resource. Through a TYPE

attribute, the browser knows the MIME type and can load a registered plug-in first and, if there are no matches for the MIME type, the browser looks for a helper application. Once the viewer plug-in is identified, the browser loads the viewer plug-in code into memory; initializes the viewer plug-in; and creates a new instance of the viewer plug-in. When the user leaves the site or closes the window, the viewer plug-in instance is deleted. When the last instance of the viewer plug-in is deleted, the plug-in code is unloaded from memory. Next, data files are downloaded to the viewer plug-in. In one implementation, the viewer plug-in downloads a data file from the dental server 102 using a suitable protocol such as a file transfer protocol (FTP). The viewer plug-in uses the downloaded file to present the treatment plan graphically to the clinician. The viewer plug-in also can be used by the treatment plan designer at the host site to view images of a patient's teeth.

FIG. 4 shows a process 230 for producing the incremental position adjustment appliances for subsequent use by a patient to reposition the patient's teeth. As a first step, an initial digital data set (IDDS) representing an initial tooth arrangement is obtained (step 232). The IDDS may be obtained in a variety of ways. For example, the patient's teeth may be scanned or imaged using X-rays, three dimensional X-rays, computer-aided tomographic images or data sets, or magnetic resonance images, among others. More details on the contact or non-contact scanners are in commonly-owned and co-pending Application Serial No. 09/169,276, filed October 8, 1998, the content of which is incorporated by reference.

A plaster cast of the patient's teeth is obtained by well known techniques, such as those described in Graber, *Orthodontics: Principle and Practice*, Second

Edition, Saunders, Philadelphia, 1969, pp. 401-415. After the tooth casting is obtained, the casting is digitally scanned by a scanner, such as a non-contact type laser or destructive scanner or a contact-type scanner, to produce the IDDS. The data set produced by the scanner may be presented in any of a variety of digital formats to ensure compatibility with the software used to manipulate images represented by the data. In addition to the 3D image data gathered by laser scanning or destructive scanning the exposed surfaces of the teeth, a user may wish to gather data about hidden features, such as the roots of the patient's teeth and the patient's jaw bones. This information is used to build a detailed model of the patient's dentition and to show with more accuracy and precision how the teeth will respond to treatment. For example, information about the roots allows modeling of all tooth surfaces, instead of just the crowns, which in turn allows simulation of the relationships between the crowns and the roots as they move during treatment. Information about the patient's jaws and gums also enables a more accurate model of tooth movement during treatment. For example, an x-ray of the patient's jaw bones can assist in identifying ankylose teeth, and an MRI can provide information about the density of the patient's gum tissue. Moreover, information about the relationship between the patient's teeth and other cranial features allows accurate alignment of the teeth with respect to the rest of the head at each of the treatment steps. Data about these hidden features may be gathered from many sources, including 2D and 3D x-ray systems, CT scanners, and magnetic resonance imaging (MRI) systems. Using this data to introduce visually hidden features to the tooth model is described in more detail below. The IDDS is manipulated using a computer having a suitable graphical user

interface (GUI) and software appropriate for viewing and modifying the images. More specific aspects of this process will be described in detail below.

Individual tooth and other components may be segmented or isolated in the model to permit their individual repositioning or removal from the digital model. After segmenting or isolating the components, the user will often reposition the tooth in the model by following a prescription or other written specification provided by the treating professional. Alternatively, the user may reposition one or more teeth based on a visual appearance or based on rules and algorithms programmed into the computer. Once the user is satisfied, the final teeth arrangement is incorporated into a final digital data set (FDDS) (step 234).

The FDDS is used to generate appliances that move the teeth in a specified sequence. First, the centers of each tooth model may be aligned using a number of methods. One method is a standard arch. Then, the teeth models are rotated until their roots are in the proper vertical position. Next, the teeth models are rotated around their vertical axis into the proper orientation. The teeth models are then observed from the side, and translated vertically into their proper vertical position. Finally, the two arches are placed together, and the teeth models moved slightly to ensure that the upper and lower arches properly mesh together. The meshing of the upper and lower arches together is visualized using a collision detection process to highlight the contacting points of the teeth.

In step 234, final positions for the upper and lower teeth in a masticatory system of a patient are determined by generating a computer representation of the masticatory system. An occlusion of the upper and lower teeth is computed from the computer representation; and a functional occlusion is computed based on interactions in the computer representation of the masticatory system. The occlusion may be determined by generating a set of ideal models of the teeth. Each ideal model in the set of ideal models is an abstract model of idealized teeth placement which is customized to the patient's teeth, as discussed below. After applying the ideal model to the computer representation, and the position of the teeth is optimized to fit the ideal model. The ideal model may be specified by one or more arch forms, or may be specified using various features associated with the teeth.

Based on both the IDDS and the FDDS, a plurality of intermediate digital data sets (INTDDSs) are defined to correspond to incrementally adjusted appliances (step 236). Finally, a set of incremental position adjustment appliances are produced based on the INTDDs and the FDDS (step 238).

Once the intermediate and final data sets have been created, the appliances may be fabricated as illustrated in FIG. 5. Common fabrication methods employ a rapid prototyping device 501 such as a stereolithography machine. A particularly suitable rapid prototyping machine is Model SLA-250/50 available from 3D System, Valencia, California. The rapid prototyping machine 501 selectively hardens a liquid or other non-hardened resin into a three-dimensional structure which can be separated from the remaining non-hardened resin, washed, and used either directly as the appliance or indirectly as a mold for producing the appliance. The prototyping machine 501 receives

the individual digital data sets and produces one structure corresponding to each of the desired appliances. Generally, because the rapid prototyping machine 501 may utilize a resin having non-optimum mechanical properties and which may not be generally acceptable for patient use, the prototyping machine typically is used to produce molds which are, in effect, positive tooth models of each successive stage of the treatment. After the positive models are prepared, a conventional pressure or vacuum molding machine 551 is used to produce the appliances from a more suitable material, such as 0.03 inch thermal forming dental material, available from Tru-Tain Plastics, Rochester, Minnesota 55902. Suitable pressure molding equipment is available under the trade name BIOSTAR from Great Lakes Orthodontics, Ltd., Tonawanda, New York 14150. The molding machine 551 produces each of the appliances directly from the positive tooth model and the desired material. Suitable vacuum molding machines are available from Raintree Essix, Inc.

Due to regulatory requirements, each production step is recorded in a device history database, which is a manufacturing database. In one embodiment, the appliances are produced in batches, each having a plurality of appliances. Each batch is stored in a bin that is bar-coded and the progress of each bin is captured when the bin completes a particular manufacturing step by scanning the bar-code associated with the bin. In this way, entries are made in the device history database in accordance with the bar-code after the completion of each manufacturing step.

Eventually, the bins reach a laser marking station that marks each aligner in the bin with a sequence identifier. In the marking station, the appliances are marked in some manner, typically by sequential numbering directly on the appliances or on tags, pouches,

or other items which are affixed to or which enclose each appliance, to indicate their order of use.

After production, the appliances can be supplied to the treating professional all at one time. Optionally, written instructions may accompany the system which set forth that the patient is to wear the individual appliances in the order marked on the appliances or elsewhere in the packaging. Use of the appliances in such a manner will reposition the patient's teeth progressively toward the final tooth arrangement.

Referring now to Fig. 6A, a process for sending messages generated during and after manufacturing is shown. The process 240 first affixes identification information to one or more bins containing one or more appliances (step 242). Next, each bin is moved through a series of manufacturing stations, and the movement of the bin to the next manufacturing station is captured (step 244). The bin history is stored in a device history database which is replicated for each appliance in the bin (step 246). Next, the process 240 checks whether a manufacturing deviation exists (step 248). If so, one or more manufacturing error messages may be sent to manufacturing people (step 250) for rapid corrective action if necessary. From step 248 or step 250, the process 240 checks whether the manufacturing information is needed by a treating professional (step 252). The access to this information may be restricted by using one or more predefined rules so that the treating professional only has access to information necessary in making a treatment decision. If the information is needed by the treating professional, the process 240 sends a message to the treating professional (step 254). From step 252 or step 254, the process 240 determines whether the information is needed by the patient (step 256). The information needed by the patient is typically near the end of the manufacturing

process, for instance when the device is expected to be shipped. From step 256, if the information is needed by the patient, the process 240 sends a message to the patient (step 258). Next, the process 240 checks whether all manufacturing operations have been completed (step 260). If not, the process 240 loops back to step 244 to continue capturing the device manufacturing history.

Fig. 6B shows a second embodiment of a system for producing appliances and scheduling appointments. First, one or more orders are received by the system (step 262). The system in turn sends an electronic message to the treating professional to confirm the order and to collect additional information if necessary (step 264). Next, models are generated from the data collected by the treating professional (step 266). The models are inspected by in-house treating professionals (step 268). The system also sends an electronic message to the treating professional who sent the order to either confirm that the model quality is acceptable and that the system will proceed with manufacturing. Alternatively, if the model quality is not acceptable, the system sends an electronic message to the ordering professional to request a reimpression of the patient (step 270). From step 268, if the quality is acceptable, the system scans the models, sets bite alignment and generates a treatment plan (step 272). Aligners are then produced (step 274) and electronic messages are sent to the treating professional and to the patient at appropriate manufacturing steps to facilitate the scheduling of an appointment between the professional and the patient (step 276). Finally, the appliances are packaged and shipped to the treating professional or the patient (step 278).

Figs. 7A-7B illustrate an exemplary usage of the system of Fig. 1. A prospective patient uses a client computer 104 and visits the web site on the dental server 106 (step

280). The client identifies a treating professional and schedules an appointment with the treating professional or a referring dentist can refer the client to the treating orthodontist (step 282). The referring dentist can visit the web site on the dental server 106 and uses one or more dental esthetic tools to show patients the potential benefits of anterior and posterior esthetic restorations and, if the patient is interested, refers the patient to the treating professional.

Once the patient requests treatment, the treating professional takes impressions and a bite registration and sends the information to the system (step 284). At the company, another professional reviews the records and decides to accept or decline the case. The impression and other patient data are then scanned (step 286). The data is then used to generate a treatment plan and the treating professional is notified of the plan (step 288).

In one embodiment, the tooth models may be posted on a hypertext transfer protocol (http) web site for limited access by the corresponding patients and treating clinicians. Since realistic models have a large volume of data, the storage and transmission of the models can be expensive and time consuming. To reduce transmission problems arising from the large size of the 3D model, in one embodiment, data associated with the model is compressed. The compression is done by modeling the teeth meshes as a curve network before transmission to the treating professional. Once the curve network is received, the 3D model is reconstructed from the curve network for the treating professional to analyze. More information on the compression is disclosed in a co-pending application having Serial No. 09/506,419, entitled, "Efficient Data

Representation of Teeth Model", and filed by Elena Pavlovskaia and Huafeng Wen on February 17, 2000, the contents of which are hereby incorporated.

The treating professional can, at his or her convenience, check the setup, and review the information sent in step 288 (step 290). The treating professionals can use a variety of tools to interpret patient information. For example, the treating professional can retrieve and analyze patient information through a reconstructed 3D model of the patient's teeth and other anatomical structures. The professional can view animations showing the progress of the treatment plan to help the treating physician visualize the pace of treatment. Using these tools, the treating professional can easily and quickly view and/or edit the treatment plan. If necessary, the treating professional can adjust one or more teeth positions at various intermediate stages of treatment. A variety of diagnostic decision-support capabilities such as automated teeth collision detection can be used to aid the treating professional in adjusting the teeth positions. When the treating professional arrives at a prescription or other final designation, the treatment information is automatically collected by the system over the Internet, thus eliminating the cost and delay associated with the traditional physical shipping of patient information.

The patient can also review the treatment plan and visualize the result using 3D imaging tools described above (step 292). After review, the aligners are generated (step 294).

Referring now to Fig. 7B, during the fabrication of the aligners, the system of Fig. 7B monitors progress and informs doctors and patients of the manufacturing stage of the aligners (step 296). This may be done in accordance with the process of Fig. 6 in one embodiment.

Next, the process of Fig. 7 determines whether the appliances are sufficiently close to a delivery point (step 298). If so, the process invites the patient to schedule appointments electronically or telephonically with a receptionist. This may be done automatically by having the patients send an email to a receptionist, or by having the patient view an on-line calendar and selecting an available time to schedule an appointment (steps 300-302).

FIG. 8 is a simplified block diagram of a data processing system 300 that may be used to develop orthodontic treatment plans. The data processing system 300 typically includes at least one processor 302 that communicates with a number of peripheral devices via bus subsystem 304. These peripheral devices typically include a storage subsystem 306 (memory subsystem 308 and file storage subsystem 314), a set of user interface input and output devices 318, and an interface to outside networks 316, including the public switched telephone network. This interface is shown schematically as "Modems and Network Interface" block 316, and is coupled to corresponding interface devices in other data processing systems via communication network interface 324. Data processing system 300 could be a terminal or a low-end personal computer or a high-end personal computer, workstation or mainframe.

The user interface input devices typically include a keyboard and may further include a pointing device and a scanner. The pointing device may be an indirect pointing device such as a mouse, trackball, touchpad, or graphics tablet, or a direct pointing device such as a touchscreen incorporated into the display, or a three dimensional pointing device, such as the gyroscopic pointing device described in U.S. Patent 5,440,326, other types of user interface input devices, such as voice recognition systems, can also be used.

User interface output devices typically include a printer and a display subsystem, which includes a display controller and a display device coupled to the controller. The display device may be a cathode ray tube (CRT), a flat-panel device such as a liquid crystal display (LCD), or a projection device. The display subsystem may also provide non-visual display such as audio output.

Storage subsystem 306 maintains the basic required programming and data constructs. The program modules discussed above are typically stored in storage subsystem 306. Storage subsystem 306 typically comprises memory subsystem 308 and file storage subsystem 314.

Memory subsystem 308 typically includes a number of memories including a main random access memory (RAM) 310 for storage of instructions and data during program execution and a read only memory (ROM) 312 in which fixed instructions are stored. In the case of Macintosh-compatible personal computers the ROM would include portions of the operating system; in the case of IBM-compatible personal computers, this would include the BIOS (basic input/output system).

File storage subsystem 314 provides persistent (non-volatile) storage for program and data files, and typically includes at least one hard disk drive and at least one floppy disk drive (with associated removable media). There may also be other devices such as a CD-ROM drive and optical drives (all with their associated removable media). Additionally, the system may include drives of the type with removable media cartridges. The removable media cartridges may, for example be hard disk cartridges, such as those marketed by Syquest and others, and flexible disk cartridges, such as those marketed by

Iomega. One or more of the drives may be located at a remote location, such as in a server on a local area network or at a site on the Internet's World Wide Web.

In this context, the term "bus subsystem" is used generically so as to include any mechanism for letting the various components and subsystems communicate with each other as intended. With the exception of the input devices and the display, the other components need not be at the same physical location. Thus, for example, portions of the file storage system could be connected via various local-area or wide-area network media, including telephone lines. Similarly, the input devices and display need not be at the same location as the processor, although it is anticipated that personal computers and workstations typically will be used.

Bus subsystem 304 is shown schematically as a single bus, but a typical system has a number of buses such as a local bus and one or more expansion buses (e.g., ADB, SCSI, ISA, EISA, MCA, NuBus, or PCI), as well as serial and parallel ports. Network connections are usually established through a device such as a network adapter on one of these expansion buses or a modem on a serial port. The client computer may be a desktop system or a portable system.

Scanner 320 is responsible for scanning casts of the patient's teeth obtained either from the patient or from an orthodontist and providing the scanned digital data set information to data processing system 300 for further processing. In a distributed environment, scanner 320 may be located at a remote location and communicate scanned digital data set information to data processing system 300 via network interface 324. Fabrication machine 322 fabricates dental appliances based on intermediate and final data set information received from data processing system 300. In a distributed environment,

fabrication machine 322 may be located at a remote location and receive data set information from data processing system 300 via network interface 324.

The invention has been described in terms of particular embodiments. Other embodiments are within the scope of the following claims. For example, the three-dimensional scanning techniques described above may be used to analyze material characteristics, such as shrinkage and expansion, of the materials that form the tooth castings and the aligners. Also, the 3D tooth models and the graphical interface described above may be used to assist clinicians that treat patients with conventional braces or other conventional orthodontic appliances, in which case the constraints applied to tooth movement would be modified accordingly.